Missed Word Rates at Increasing Listening Speeds of High-Level Japanese Speakers of English

NITTA Haruhiko, OKAZAKI Hironobu, Walter KLINGER

1. Introduction

That listening ability typically decreases as the speed of the heard words increases is an obvious enough phenomenon, and has been reported in a number of experiments. Tomita (1998) used ordinary, fairly slow, and very slow stimulus material with Japanese first-year university students, and confirmed that increased speech speed affects comprehension. Griffiths (1992) reported a similar result using slow, average, and fast speeds with lower-intermediate Japanese elementary school teachers. Okazaki & Nitta (2005) did not investigate a relationship at different speeds, but did report that Japanese university students missed about 50% of the words spoken at native speaker speed, although they knew all the vocabulary in written form. The phenomenon may be understood in this anecdote: "In listening to conversation, movies, or news, there are parts which I cannot catch. When there are few of these parts, they don't interfere with my understanding the general content, but as they increase, the general meaning gets blurred, and I end up not understanding the content at all." The phenomenon is not limited to language learners. Wingfield, Lombardi & Sokol (1984) used magazine articles and essays with native speakers, and re-

ported a decrease in the number of words accurately heard as the speaking speed increased.

We investigated increase in speech speed as a cause of missed or mistaken words in heard sentences. Our experiment did not focus on evaluating comprehension, but on counting the number of words missed as speech speed increased. We used 60 every day English conversational sentence-length passages as the stimulus material, with high-level Japanese non-native speakers of English and native speakers of English as the subjects. The hypotheses and points we wished to clarify were as follows:

i. As the speech rate increases, the number of error words (words not caught at all and words heard mistakenly) will increase for the Japanese subjects, although all the vocabulary is familiar to them in written form.

ii. Native speakers will generally not miss any words despite an increase in speech rate.

iii. The missed words of the Japanese subjects will mostly be unaccented and unstressed function words, while content words will generally not be missed or mistaken.

iv. Is there an upper limit of speech speed for high-level Japanese speakers of English?

2. Method

2a. Stimulus Material

We collected spoken examples from popular American TV comedy shows such as "Friends," "Sex and the City," and "Beverly Hills 90210," as representative of material that is produced by native speakers for native speakers, is designed to be typical American casual conversational dia-

logue, and is not produced especially for foreign language study. Sentences were selected for a single speaker with no overlapping voices of other people, no mumbled or cut ends of words or sentences, and no background noise or other obstacles for listening. Male voices appeared in 28 sentences and female voices in 32. Sentence transcripts were verified by a native speaker. Factors affecting listening comprehension include known versus unknown vocabulary (including idioms) and grammar, and speech transformations such as linking, assimilation, elision, and so on. These are often problems for beginner level and intermediate level students, and they may affect advanced students as well. In our experiment, we focused on speech speed, so we eliminated potentially unknown vocabulary as much as possible. **Appendix 1** gives the list of sentences.

There was a relatively small concern that the subjects might have heard the sentences before, perhaps during personal viewing or as material in language lessons or tests. However, the amount of material available in each of these series is enormous, so the chances seemed remote that they would be recognized ; furthermore, the examples selected were not in any context which might stimulate remembrance.

The sentences were separated into 5 groups according to their spoken speeds as measured in syllables per second (sps) : 4 sps, 5 sps, 6 sps, 7 sps, and 8 sps. Each group contained 12 examples. Most examples were sentence-length, and some were two short sentences. The speed of sentences was measured with the open source software, WaveSurfer, as depicted in **Figure 1**. The syllables in the sentences were counted manually. Material of exactly 4 sps or 5 sps was difficult to find, so material of plus or minus 0.2 sps was included in the nearest group ; e.g., sentences of from 3.8 sps to 4.2 sps were included in the 4 sps group. Sometimes only

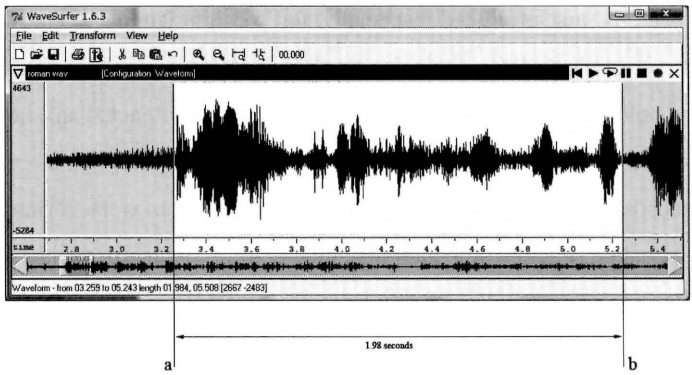


Figure 1. Measuring the Speech Time of a Sentence on the WaveSurfer.

part of a sentence, the part that matched the desired speed rate, was used in the test evaluation, though subjects heard and responded to the full sentence.

2b. Selection of Subjects

High-level Japanese non-native speakers of English (NNSE) and native speakers of English (NSE) participated in the experiment by listening to the sentences and typing in what they heard. The NNSE also translated what they heard into Japanese. Japanese subjects were required to have a TOEIC® score of at least 860, but were not to consider themselves as equal to native speakers in listening ability. The distribution of the TOEIC® score of the 31 Japanese subjects is shown in **Figure 2**. The average score was 923.3[1].

The Japanese subjects were occupied in such capacities as university lecturer, book publisher staff, and foreign-affiliated or foreign-financed company staff; many used English on a daily basis. 20 of the 31 had attended university and/or graduate school in English-environment countries, and

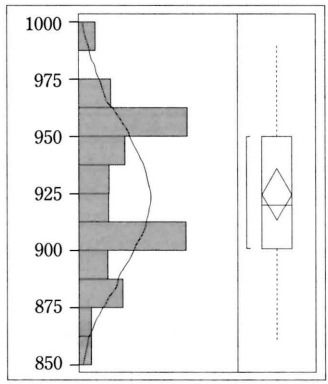


Figure 2. TOEIC® Score Distribution of Japanese Subjects.

some had internships after graduation. These 20 had an average of 4.6 years of study abroad. Of the other 11, while they did not have periods of formal study abroad, many had experiences of overseas business travel and short-term and long-term overseas residence. The average length of overseas stay in an English-language environment of the 31 Japanese subjects was 3.5 years.

The qualification for native English speakers was at least high school graduation. Of the 31 native speakers, 22 were American, 2 Canadian, 2 Australian, 2 New Zealander, and 1 each of Irish, English (England), and Indian (India). Occupations included university lecturer, university and graduate school student, company and government employee, pilot, and homemaker.

Both NNSE and NSE subjects were recruited through the personal requests of the researchers, word-of-mouth, and information posted on web sites for language teachers. Participants received a small honorarium.

Figure 3. Part of the Dictation Page.

2c. Testing Procedure

Testing was performed over the internet, which the subjects accessed with their own computers. **Figure 3** shows part of the Dictation Page, where subjects first logged in to the software system. When the sound icon was pressed, the audio for that sentence played. The icon could be pressed any number of times. When the subjects felt they had understood as well as they could, they typed the sentence into the Text Box. NSE subjects were informed, "You do not need to worry about capital letters or commas or periods. You do not need to worry about spelling too much if you are uncertain about the spelling of a word. Please try to type the words as exactly as you hear them. For example, if you hear *we're*, type *we're* and not *we are*." Japanese subjects were given this information in Japanese. There was no time limit; subjects could freely stop and continue the test at their convenience, even on different days. NSE subjects typed in what they heard only in English, while NNSE typed in what they heard in English and also their translation into Japanese of what they had heard. (While this experiment did not analyze the Japanese subjects' comprehension but only counted their error words, we wanted a translation

into Japanese to confirm that the subjects were familiar with the words they heard.)

After typing the sentence, subjects pressed the Confirm symbol, as indicated by the large number "3" in **Figure 3**. Once pressed, the Confirm symbol turned into a checkmark, and the sentence could not be listened to again nor modifications in typing made. When all 60 sentences were finished on the Dictation Page, the subjects clicked a confirmation button in order to proceed to the Vocabulary Confirmation Page, which revealed the sentences in written form. There, subjects typed in any unknown vocabulary, i.e., any word they did not know the meaning of. Once the subjects had proceeded to the Vocabulary Confirmation Page, they were unable to return to the Dictation Page (thus they were unable to fill in Text Boxes after having seen the answers).

2d. Evaluation and Grading Procedure

Grading was performed by counting error words in the typed dictation. In principle, words that were missed (subjects did not type the word), or mistaken (subjects typed the wrong word), were counted.

In the case of words that had reduced or elided sounds, judgment was attempted on the subject's comprehension. For example, if the stimulus material sound was *I'm or gonna or wanna*, but the subject wrote *I am or going to or want to*, it was not considered an error. However, if the stimulus sound was *I'm* but the subject typed *I*, we decided that the subject missed the *am* part of the phrase, and counted it as 1 error. In the sentence *I'd say about a month*, all NSE wrote *I'd* while 4 NNSE wrote *I would* (=no error), 3 NNSE wrote *I* (=error), and 1 NNSE wrote *I've* (=error). In the sentence *I'm not great at the advice*, all NSEs wrote *I'm*, while 5

NNSE wrote *I am* (=no error), and 1 NNSE wrote *I do not* (=error). In the sentence *I'll pick you up*, 1 NSE and 6 NNSE wrote *I will* (=no error), 4 NNSE wrote *I* (=error), and 1 NNSE wrote *I'd* (=error).

There were two proper nouns in the material, *Paris and Steve*. We excluded both for all subjects in both evaluation methods after realizing that, while the words might be familiar enough in context, they seemed to be unexpected appearing in the test, and many subjects missed or mistook them. In the sentence *If I win, you do not move to Paris*, all NSE recognized the word *Paris*, but 8 NNSE did not (4 left it blank, 2 wrote *parents*, 1 wrote *past*, and 1 *palace*). In the sentence *Anyway, is this guy really as bad as Steve says he is?*, only 1 NSE wrote *Steve*, 2 left it blank, 1 wrote *she*, and all the other NSE wrote *he*. None of NNSE recognized *Steve*; 3 wrote *he* and all the others left it blank.

Unknown vocabulary was also excluded from both evaluation methods, but only for those subjects who reported them as unknown. Unknown vocabulary was verified by the subjects on the Vocabulary Confirmation Page. The NSE had no unknown vocabulary, while 6 NNSE had a total of 8 unknown words (3 subjects did not know *fabulous*, 2 *stepfather*, and 1 each of *thrown*, *stuff*, and *divisional*). Small errors in spelling were not counted as errors when we were confident that they were simple spelling errors and not attempts to write a different word (e.g., *parants*, *havn't*, *aroud*, *warrying*, *sombody*, *excactly*, *prepeard*, *jurney*, *divisonal*, *buillding*). One instance of an error in word order was not counted as a mistake: in the stimulus sentence *It would have really been that easy?*, 4 NNSE and 21 NSE subjects wrote Would it have really been that easy?

3. Method

Four charts and graphs show the results of the experiment.

Table 1. Average Number of Times that Subjects Listened to Stimulus Sentences.

Figure 4. Missing Word Rate : Strict Evaluation

Figure 5. Missing Word Rate : Adjusted Evaluation

Figure 6. Missing Word Rate : Content Word Results

3a. Average Number of Times that Subjects Listened to Stimulus Sentences.

We recorded the number of times the stimulus sounds icons were clicked by the subjects in order to repeatedly listen to the sentences. **Table 1** shows the data for NNSE (non-native speakers of English) and NSE (native speakers of English) in each of the 5 groups of speed rates. The total number of words heard and the number of words evaluated in each group is also listed.

For each stimulus sentence at 4 sps, NSE subjects listened an average of 1.8 times while NNSE listened 5.2 times. At 8 sps, NSE listened 3 times and NNSE almost 11 times. NSE listened few times and answered almost always correctly. The comparatively large number of times NNSE listened indicates their relative difficulty in listening, or at least their need for more

Speed	Total Words Heard	Words Evaluated	NNSE(times)	NSE(times)
4sps	116	106	5.2	1.8
5sps	143	117	7.7	2
6sps	144	126	8.1	2.4
7sps	164	141	10.2	2.7
8sps	161	149	10.6	3

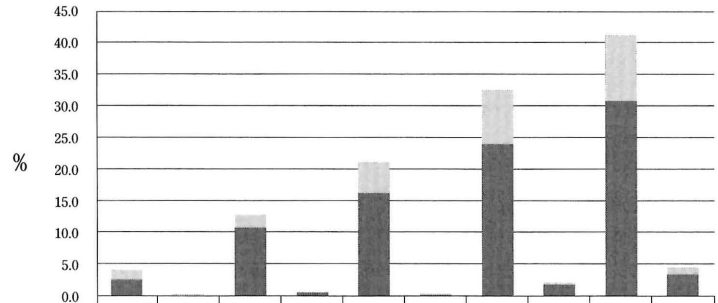
Table 1. Average Number of Times that Subjects Listened to Stimulus Sentences.

intensive concentration in listening.

The increasing number of listening times for higher speeds does not necessarily mean that higher speed was the only problem in listening comprehension, as the number of words also increased in sentences spoken at higher speeds. In continuous speech, listeners need to become habituated with the use of language-specific duration cues (Cutler & Butterfield, 1990) and intonational cues (Butterfield & Cutler, 1990) to separate the word stream into understandable segments and individual words. Repeated listening to the stimulus sentences must help to mitigate this problem. Repeated listening is also necessary to remember sentences that cannot be held in memory after one or two listenings. Guessing words from their context is a technique that is typically used in listening, and it was sometimes employed by subjects in this experiment.

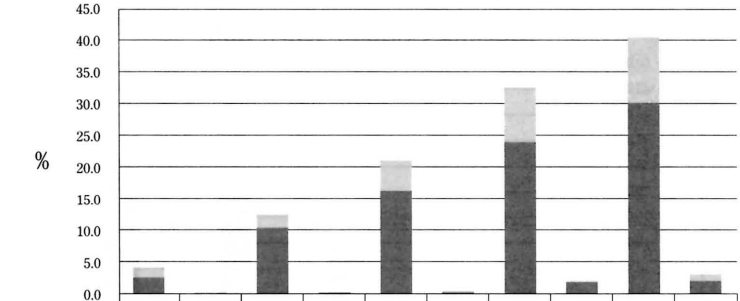
3b. Missing Word Rate : Strict Evaluation Results

Appendix 2 describes each speed for NSE and NNSE. The average moment is described in bar graph **Figure 4**. The total indicates the average



	NNSE 4sps	NSE 4sps	NNSE 5sps	NSE 5sps	NNSE 6sps	NSE 6sps	NNSE 7sps	NSE 7sps	NNSE 8sps	NSE 8sps
Total	4.2	0.3	13	0.7	21.2	0.4	32.7	2.4	41.3	4.7
Content Word	1.5	0.1	2.1	0	4.8	0.1	8.7	0.4	10.5	1.1
Function Word	2.7	0.2	10.9	0.7	16.4	0.3	24.0	2	30.8	3.6

Figure 4. Missing Word Rate : Strict Evaluation Results.



	NNSE 4sps	NSE 4sps	NNSE 5sps	NSE 5sps	NNSE 6sps	NSE 6sps	NNSE 7sps	NSE 7sps	NNSE 8sps	NSE 8sps
■+■ Total	4.2	0.3	12.6	0.3	21.2	0.4	32.7	2.3	40.6	3.3
■ Content Word	1.5	0.1	2.1	0	4.8	0.1	8.7	0.3	10.5	1.1
■ Function Word	2.7	0.2	10.5	0.3	16.4	0.3	24.0	2	30.1	2.2

Figure 5. Missing Word Rate : Adjusted Evaluation.

moment, classified into content words and function words below the total.

For the NNSE subjects, at 4 sps the MWR (missing word rate) was 1.5% for content words, 2.7% for function words, total 4.2%. At 5 sps, it jumped to 13%, and rose about 10% for every increase of 1 sps.

For NSE subjects, no rising trend in error words was noticeable up to 6 sps. At 7 sps there was a small rise in MWR, ending at 4.7% at 8 sps.

The decline for NSE between 5 sps and 6 sps is attributable to many NSE subjects omitting the relative pronoun that in their written dictation. This non-critical error was eliminated in the Adjusted Evaluation as described in **Figure 5**.

A clear difference can be seen in the listening ability at any speech speed of NSE and NNSE subjects. The degree of difficult for NNES at 4 sps is about the same degree of difficulty for NES at 8 sps. (See the Wilcoxon/Kruskal-Wallis tests in **Appendix 3**.)

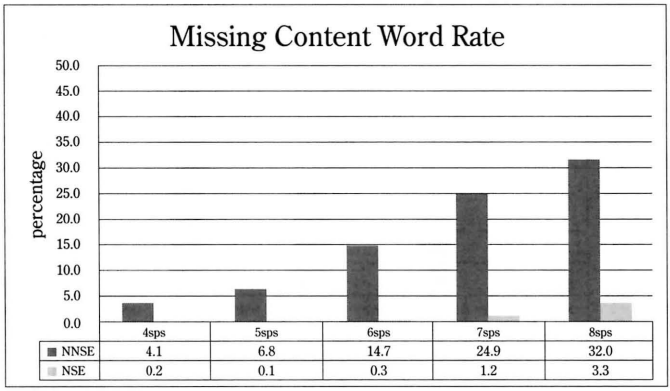


Figure 6. Missing Word Rate : Content Word Results.

3c. Missing Word Rate : Adjusted Evaluation

Figure 5 shows the results after the removal of responses that we evaluated as not being true errors for our purposes. Such errors were words or phrases that were equivalent or near in meaning to the correct words or phrases. We assumed that subjects heard the words correctly, but replaced them with substitute words. For example, a number of subjects replaced *I'm going to* with *I will*. Quite a number of subjects dropped the relative pronoun *that*, which we decided was common and legitimate in conversational situations, and it was not counted as an error in this Adjusted Evaluation. If the test had not been a written dictation, but an immediate oral repetition of what the subject heard, the response might have been more accurate.

The Adjusted Evaluation shows some slight though not dramatic differences with the Strict Evaluation for both NSE and NNSE. In particular, the anomaly of NSE performing worse with function words at 5 sps than at 6 sps was cleared up.

3d. Missing Word Rate : Content Word Results

Figure 6 shows the rate of errors in content words, which are usually more essential to understanding the meaning of a sentence than are function words. NNSE subjects erred with 4.1% of the content words at 4 sps and 32% at 8 sps.

4. Discussion

Nitta, Okazaki & Klinger (2010) found that the average speaking rate in American films and TV series was 5 sps. The present experiment used rates from 4 sps to 8 sps and was devised to determine how much the Missing Word Rate (MWR), or error rate, would go up as rates of speech increased.

4a. NNSE subjects

While we imagined that advanced level Japanese speakers of English (NNSE) would have little difficulty at a slower than average rate, we found a MWR of 4.2% at 4 sps, even after subjects listened to the stimulus sentences several times, compared to the native speakers of English (NSE) error rate of 0.3%. An error rate of about 4 wrong words per 100 words is probably not enough to impair general comprehension, though it may depend on the situation. At 5 sps, the MWR of the NNSE rose sharply to 12.6%, a level which may be unstable for good comprehension. 5 sps is the average speed among native speakers, and we had expected advanced level NNSE with high TOEIC® scores to do better than the results indicated. At 6 sps, the MWR rose to 21.2%, meaning that 21 words in 100 were not understood, a level that would make a verbal or written reconstruction of the heard sentence difficult to achieve. In the 6 sps stimulus

sentence *You know what shoes would look great with this ring?*, only one in three of the NNSE subjects identified both *shoes* and *ring*, and in *He got thrown out of his last 3 schools*, less than half identified *last 3 schools*. The Missing Word Rate at 7 sps was 32.7%, and at 8 sps, just over 40%. Sentence comprehension and rebuilding would be difficult if not impossible at this rate.

We had hypothesized that NNSE error words would be mainly unstressed function words like prepositions, pronouns, possessive adjectives, and unstressed adverbs; however, a percentage of content words were missed at even slower speeds (in particular, *dogs* and *win*), a situation we had not expected.

4b. TOEIC scores

We imagined that Missing Word Rates would be in inverse proportion to TOEIC® scores, but we were unable to confirm it from this experiment.

4c. NSE subjects

The native speaker of English (NSE) errors at 4-6 sps can be considered to be minor and irrelevant. The NSE had an error rate of 4.7% (Adjusted 3.3%) at 8 sps, while we had hypothesized little or no errors. An example of a content word error was in the sentence, *I'll pick you up. Is eight ok?* Six of the 31 NSE subjects could not catch the word *eight*. The results do not necessarily disprove the hypothesis that NSE can catch everything or very nearly everything even at high speeds, particularly if the speech is in context and is listened to closely and not distractedly. However, from the results of this experiment, we might identify the point where the speaking rate begins to have an effect on listening ability for NSE at between 7 and

8 sps.

4d. American and Non-American NSE

The stimulus questions were spoken in American English. We guessed that the 9 non-American NSE subjects would have some difficulties compared with the 22 American NSE subjects, but the results showed that all the non-Americans matched and even excelled the American NSE subjects. Though we cannot confirm it statistically, we might conjecture that, given the opportunity to repeatedly listen to source information, natives of a non-American English-environment country can understand American English well. It may also suggest that American English is widely understood because of the enormous influence of American film and TV media. The non-Americans listened 2.7 times per sentence on average, while the Americans listened 2.2 times. This result may indicate relative difficulties in listening, or perhaps something completely different, like efforts to finish the test more conscientiously rather than more quickly.

4e. General Discussion

For the most part, with the notable exception of *Paris* and *Steve*, the vocabulary used was fairly standard, everyday vocabulary. For both NNSE and NSE, we must take into consideration that the lack of context in understandable situations made some words difficult to catch. We might guess that the error words would be heard more accurately if they were in more understandable context. We might also guess that the error words would be heard more accurately if they were spoken more slowly. From the results of our experiment, we can almost verify that words spoken at faster speeds are harder to catch than words spoken at slower speeds, but in this experiment we cannot get complete statistical support. We could

make a strong claim only if our sentences had the same content at each speed.

Our experiment was not designed to check and evaluate the subjects' comprehensions or to determine how much comprehension decreases as speech speeds increase. It was designed only to record and evaluate to what extent error words increase as speech speeds increase. From the results of our experiment, we can confirm that advanced Japanese speakers of English miss or mistake words in spoken English conversation increasingly as speech speeds increase, and that NSE are much better than NNSE at hearing words accurately at any rate of speech speed.

5. Conclusion

This experiment confirmed that advanced Japanese speakers of English missed an increasing number of words in listening to English conversation as speech speeds increased. The rate that the Japanese speakers of English missed words rose sharply after 6 sps. This tells us that Japanese, even those who have learned English well enough to reach a high level of ability as defined by a standard test such as the TOEIC®, still need to have much more training and practice in order to follow the natural conversation of native speakers. When it comes to learning English, our NNSE subjects had some of the best backgrounds and experiences possible among all Japanese students of English. Such experiences were still not good enough for them to cope with English spoken at 7 or 8 sps.

Japanese often blame themselves when they come across some auditory information that they cannot catch or understand. This experiment suggests that there is a point in speaking speed that is not easy to break through or cross over, despite high levels of learning and ability. A similar

level may exist for non-native speakers of other languages as well. Most motivated NNSE will read as many books, magazines, and newspapers as they can, watch the news, movies and TV shows, spend time in foreign countries, and generally do everything they can think of to make their English skills better. We are at a loss to give any further suggestions on how to definitely overcome the speed barrier.

As NSE sometimes missed words at 7 and 8 sps, we can say that those speeds are fast even for NSE. As those speeds mark an upper limit for NNSE, we can venture to say that it is unrealistic to expect that NNSE are able or should be able to listen well at that speed.

In this experiment, subjects were free to listen to sentences repeatedly. If any of the subjects, NSE and NNSE alike, were only allowed one shot at listening, the results unmistakably would have been much worse.

We cannot show the relations between MWR and comprehension at this time, though we hope to develop this theme in future research.

Acknowledgment

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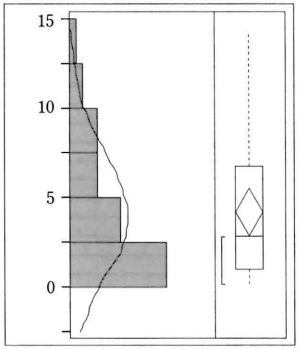
Appendix 1. List of Sentences. (Phrases in brackets were heard but not evaluated.)

4 sps	**SPS**
I'm sure it's gonna be just fine. I'd say about a month.	3.8
(Oh yeah.) We had a really good talk.	4.0
(Well then) Maybe it's time we all moved on.	4.2
(So) You took off my pants and shoes?	3.8
(But) is there any chance you would take me back?	4.0
I do not want her babysitting our child.	4.0
(OK? and remember,) if I win you do not move to Paris.	4.0
You have to name all the states in six minutes.	4.0
No, she doesn't want to see you right now.	3.8
If you let me have him, then I will really owe you one.	3.9
Do you not like all dogs?	3.8
I want my key back	3.8
5 sps	
He paid in full ; what more is there to talk about?	5.1
(Oh my god. What if... what if they get married?) Then he'd be the stepfather of my child.	5.1
I think maybe one of them is dying.	4.9
I'm not great at the advice.	4.8
(Oh, hey! How about right above the TV? That way,) it will be the first thing that you see when you walk in the door!	5.0
Nothing is good enough for her	5.1
I just don't want him to meet anybody until I am over my crush. (And I will get over it.)	5.2
I just figured out who you are	5.2
I can think of no two people better prepared for the journey.	5.2
We can't do it again soon.	5.1
You can't take him away from me.	5.2
I never should have broken up with you because you were overweight.	5.2
6 sps	
You know what shoes would look great with this ring?	5.8
I was kind of hoping you'd stay over.	6.0
She's been away all week visiting her parents.	6.2
(Well) With everything that's been going on lately, (I....) I haven't exactly been the perfect boyfriend.	6.2
I hope you're going somewhere with this.	6.0
(You know) You don't make a very good first impression.	6.2
(Oh, goodie! Yes! Oh!) We haven't done the secret thing in a long time.	5.8
I guess I'll have my stuff picked up.	6.0
(But I,) I wanted to talk to you about your options.	6.1
(You know) I think I'm just gonna take off and break up with her over the phone	6.1
(Because I hit him. He provoked) It was as much his fault as it was yours.	5.8
He got thrown out of his last three schools.	6.2
7 sps	
Did you know I was in there?	7.1
It was at the front door when I got home. Somebody sent it to us.	7.1
She goes and makes a date with a guy on the same night she has plans with me?	6.9
(First of all, he...) He's never gonna tell her how he feels about her.	7.1
(Isn't it funny how we kept running into each other?) It's as if someone really wants us to be together.	7.0
Those two will never know what hit them.	6.9
There's a great gym right around the corner from your building.	6.9
(Well, now's a good time.) I'm on my way to have my ears cut off.	7.0
(Damn it.) One of these days I'm gonna have to start listening when he talks about his job.	7.0
How come we have one extra place setting?	7.2
Wouldn't you understand that they had to know?	7. 2
You wanna talk now? I don't have class till two.	6.8
8 sps	
And it would have hurt a lot less if I had have finished that last beer.	8.2
It would have really been that easy?	7.8
Do you really not know where I'm going with this?	7.9
Because I think I just heard her moving around in there	8.2
(No!) Because then you're gonna have to tell them what we did!	7.9
So what do you wanna be when you grow up?	8.2
So why don't you just go back to your place and give us some privacy?	8.2
(You know) Let me get it out before it sets. (Oh I have something you could wear.)	8.0
You know and then I started worrying about this big divisional meeting that I have later today	8.1
You're gonna want him to eat his heart out so you're gonna have to look fabulous!	8.0
Anyway, is this guy really as bad as Steve says he is?	8.0
(So....) I'll pick you up. Is eight ok?	8.2

Appendix 2. Univariate Analysis.

4 sps (NNSE)



Quantile

100.0%	Maximum Value	13.200
99.5%		13.200
97.5%		13.200
90.0%		10.200
75.0%	Upper quartile	6.600
50.0%	Median	2.800
25.0%	Lower quartile	0.900
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	Minimum Value	0.000

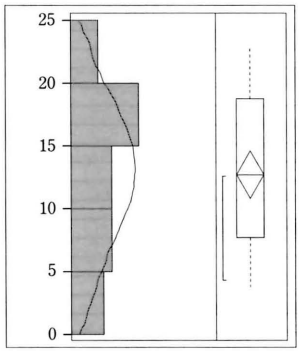
Moments

Mean	4.1580645
Standard Deviation	3.712122
Standard error of the mean	0.6667168
Upper confidence limit for the mean (95%)	5.5196818
Lower confidence limit for the mean (95%)	2.7964472
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	4.158065	2.796447	5.519682
Dispersion	Sigma	3.712122	2.966401	4.961895

5 sps (NNSE)



Quantile

100.0%	Maximum Value	23.100
99.5%		23.100
97.5%		23.100
90.0%		22.040
5.0%	Upper quartile	18.800
50.0%	Median	12.800
25.0%	Lower quartile	7.700
10.0%		3.580
2.5%		2.600
0.5%		2.600
0.0%	Minimum Value	2.600

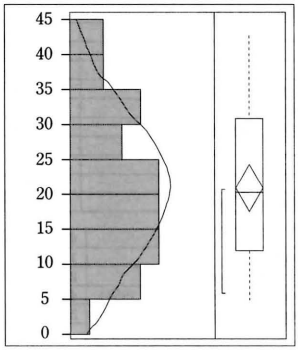
Moments

Mean	12.993548
Standard Deviation	6.4547107
Standard error of the mean	1.1593003
Upper confidence limit for the mean (95%)	15.361155
Lower confidence limit for the mean (95%)	10.625941
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	12.99355	10.62594	15.36116
Dispersion	Sigma	6.45471	5.15804	8.62784

6 sps (NNSE)



Quantile

100.0%	Maximum Value	43.700
99.5%		43.700
97.5%		43.700
90.0%		3.340
75.0%	Upper quartile	31.000
50.0%	Median	20.600
25.0%	Lower quartile	11.900
10.0%		8.860
2.5%		4.000
0.5%		4.000
0.0%	Minimum Value	4.000

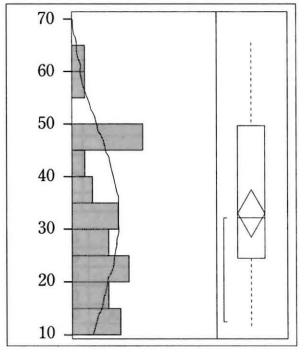
Moments

Mean	21.232258
Standard Deviation	10.77093
Standard error of the mean	1.9345161
Upper confidence limit for the mean (95%)	25.183067
Lower confidence limit for the mean (95%)	17.281449
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	21.23226	17.28145	25.18307
Dispersion	Sigma	10.77093	8.60718	14.39721

7 sps (NNSE)



Quantile

100.0%	Maximum Value	64.500
99.5%		64.500
97.5%		64.500
90.0%		9.600
75.0%	Upper quartile	47.500
50.0%	Median	30.500
25.0%	Lower quartile	23.400
10.0%		11.300
2.5%		10.600
0.5%		10.600
0.0%	Minimum Value	10.600

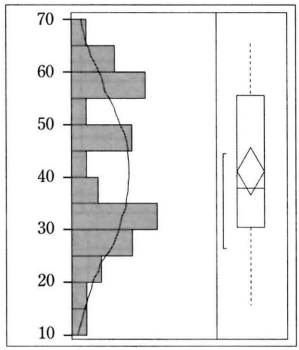
Moments

Mean	32.664516
Standard Deviation	14.778578
Standard error of the mean	2.654311
Upper confidence limit for the mean (95%)	38.085342
Lower confidence limit for the mean (95%)	27.24369
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	32.66452	27.24369	38.08534
Dispersion	Sigma	14.77858	11.80974	19.75413

8 sps (NNSE)



Quantile

100.0%	Maximum Value	66.200
99.5%		66.200
97.5%		66.200
9.0%		62.960
75.0%	Upper quartile	57.000
50.0%	Median	36.900
25.0%	Lower quartile	28.900
10.0%		22.520
2.5%		14.800
0.5%		14.800
0.0%	Minimum Value	14.800

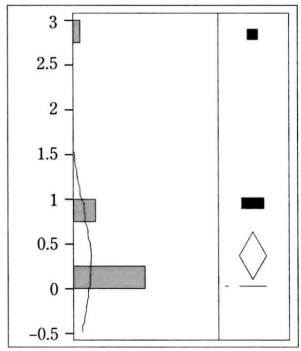
Moments

Mean	41.329032
Standard Deviation	15.312461
Standard error of the mean	2.7501992
Upper confidence limit for the mean (95%)	46.945688
Lower confidence limit for the mean (95%)	35.712376
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	41.32903	35.71238	46.94569
Dispersion	Sigma	15.31246	12.23637	20.46776

4 sps (NSE)



Quantile

100.0%	Maximum Value	2.8000
99.5%		2.8000
97.5%		2.8000
90.0%		.9000
75.0%	Upper quartile	0.0000
50.0%	Median	0.0000
25.0%	Lower quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	Minimum Value	0.0000

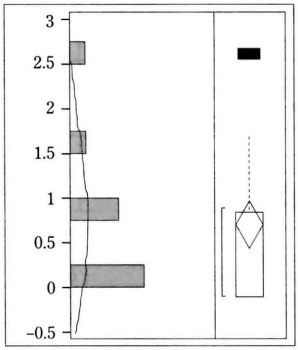
Moments

Mean	0.2645161
Standard Deviation	0.5924798
Standard error of the mean	0.1064125
Upper confidence limit for the mean (95%)	0.4818395
Lower confidence limit for the mean (95%)	0.0471928
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	0.2645161	0.0471928	0.4818395
Dispersion	Sigma	0.5924798	0.4734576	0.7919519

5 sps (NSE)



Quantile

100.0%	Maximum Value	2.6000
99.5%		2.6000
97.5%		2.6000
90.0%		2.4200
75.0%	Upper quartile	0.9000
50.0%	Median	0.9000
25.0%	Lower quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	Minimum Value	0.0000

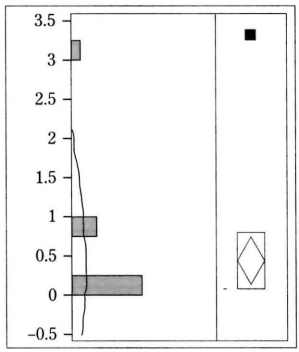
Moments

Mean	0.7064516
Standard Deviation	0.8481099
Standard error of the mean	0.152325
Upper confidence limit for the mean (95%)	1.0175408
Lower confidence limit for the mean (95%)	0.3953624
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	0.7064516	0.3953624	1.017541
Dispersion	Sigma	0.8481099	0.6777347	1.133646

6 sps (NSE)



Quantile

100.0%	Maximum Value	3.2000
99.5%		3.2000
97.5%		3.2000
90.0%		0.8000
75.0%	Upper quartile	0.8000
50.0%	Median	0.0000
25.0%	Lower quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	Minimum Value	0.0000

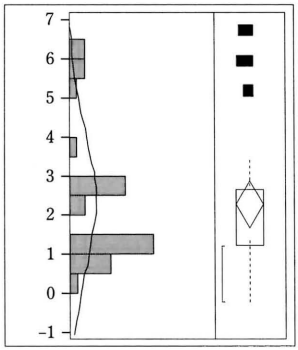
Moments

Mean	0.3870968
Standard Deviation	0.8228981
Standard error of the mean	0.1477969
Upper confidence limit for the mean (95%)	0.6889382
Lower confidence limit for the mean (95%)	0.0852553
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	0.3870968	0.0852553	0.688938
Dispersion	Sigma	0.8228981	0.6575877	1.099946

7 sps (NSE)



Quantile

100.0%	Maximum Value	6.4000
99.5%		6.4000
97.5%		6.4000
90.0%		5.7000
75.0%	Upper quartile	2.8000
50.0%	Median	1.4000
25.0%	Lower quartile	1.4000
10.0%		0.7000
2.5%		0.0000
0.5%		0.0000
0.0%	Minimum Value	0.0000

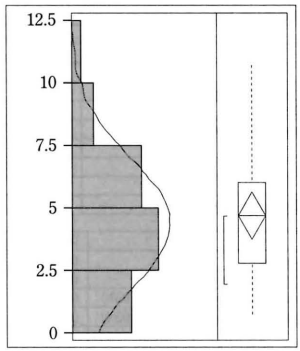
Moments

Mean	2.3870968
Standard Deviation	1.7630923
Standard error of the mean	0.3166607
Upper confidence limit for the mean (95%)	3.0338043
Lower confidence limit for the mean (95%)	1.7403893
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	2.387097	1.740389	3.033804
Dispersion	Sigma	1.763092	1.408908	2.356679

8 sps (NSE)



Quantile

100.0%	Maximum Value	10.700
99.5%		10.700
97.5%		10.700
90.0%		.580
75.0%	Upper quartile	6.000
50.0%	Median	4.700
25.0%	Lower quartile	2.700
10.0%		2.000
2.5%		0.700
0.5%		0.700
0.0%	Minimum Value	0.700

Moments

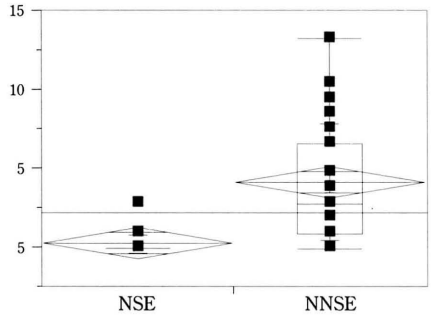
Mean	4.6967742
Standard Deviation	2.4320751
Standard error of the mean	0.4368136
Upper confidence limit for the mean (95%)	5.5888665
Lower confidence limit for the mean (95%)	3.8046818
N	31

Probit Analysis / Parameter Estimation

	Parameters	Estimate	95%LCL	95%UCL
Location	Mu	4.696774	3.804682	5.588867
Dispersion	Sigma	2.432075	1.943500	3.250890

Appendix 3. One-way analysis of variance (AVONA).

4 sps



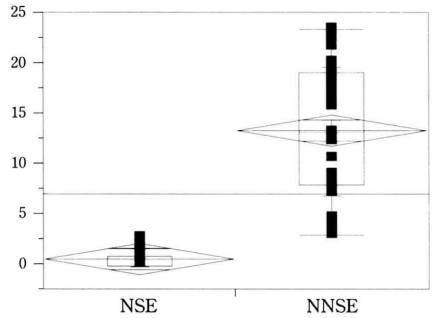
Wilcoxon/Kruskal-Wallis (Rank Sums)

	N	Sum of Scores	Mean Score	Mean-Mean0/Std Dev Under H0
NSE	31	615.5	19.8548	-5.375
NNSE	31	1337.5	43.1452	5.375

Two-Sample Test (Normal approximation)

S	Z	p-value (Prob>|Z|)
1337.5	5.37526	<.0001

5 sps



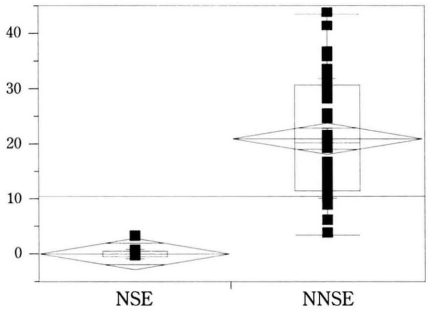
Wilcoxon/Kruskal-Wallis (Rank Sums)

	N	Sum of Scores	Mean Score	Mean-Mean0/Std Dev Under H0
NSE	31	497.5	16.0484	-6.802
NNSE	31	1455.5	46.9516	6.802

Two-Sample Test (Normal approximation)

S	Z	p-value (Prob>|Z|)
1455.5	6.80200	0.0000

6 sps



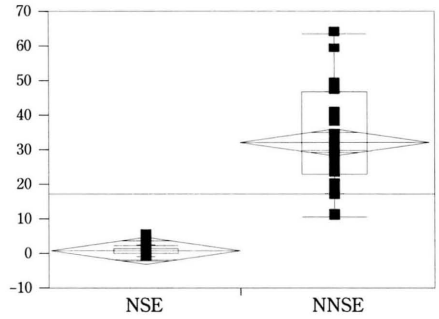
Wilcoxon/Kruskal-Wallis (Rank Sums)

	N	Sum of Scores	Mean Score	Mean-Mean0/Std Dev Under H0
NSE	31	496	16.0000	-6.919
NNSE	31	1457	47.0000	6.919

Two-Sample Test (Normal approximation)

S	Z	p-value (Prob>|Z|)
1457	6.91939	0.0000

7 sps



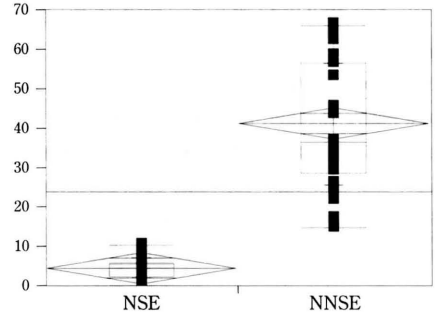
Wilcoxon/Kruskal-Wallis (Rank Sums)

	N	Sum of Scores	Mean Score	Mean-Mean0/Std Dev Under H0
NSE	31	496	16.0000	-6.780
NNSE	31	1457	47.0000	6.780

Two-Sample Test (Normal approximation)

S	Z	p-value (Prob>|Z|)
1457	6.77952	0.0000

8 sps



Wilcoxon/Kruskal-Wallis (Rank Sums)

	N	Sum of Scores	Mean Score	Mean-Mean0/Std Dev Under H0
NSE	31	496	16.0000	-6.764
NNSE	31	1457	47.0000	6.764

Two-Sample Test (Normal approximation)

S	Z	p-value (Prob>|Z|)
1457	6.76436	0.0000

Abstract

This experiment investigated increase in speech speed as a cause of missed or mistaken words by listeners. We used 60 conversational sentences from popular American TV shows in a listening test with 31 native speakers of English (NSE) and 31 high-level Japanese non-native speakers of English (NNSE). The error rate of the NNSE rose steadily from 4.2% with sentences spoken at 4 syllables per second, to 12.6% at 5 sps, to 21.2% at 6 sps, to 32.7% at 7 sps, and to 40.6% at 8 sps, despite opportunities for repeated listening to the material, while NSE reached a high of only 3.3% error words at 8 sps. We confirm that NNSE increasingly have errors in listening to English conversation as speech rates increase, and suggest that there is a point in speaking speed that is not easy to break through for listening ability even for high-level non-native speakers.

1 TOEIC® rates a score of 860 to 990 as "A" Level. A person in that rank "Can usually communicate adequately as a non-native speaker. Within his/her own realm of experience, he/she is capable of sufficient understanding and can typically respond with appropriate expressions even about topics outside his/her field of specialization. Although speech is not equivalent to that of a native speaker, he/she has a strong grasp of vocabulary, grammar, and structure and also has the ability to use the language relatively fluently" (Reference : http : //www.toeic.or.jp/toeic/pdf/data/proficiency.pdf). TOEIC® rates a score of 923 as "Ability to communicate effectively in almost any situation" (Reference : http : //www.etscanada.ca/pdf/eng/TOEICResumeScore.pdf).